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CONTRIBUTIONS TO THE SCIENCE OF NUTRITION

A TRIBUTE TO THE LIFE AND WORK OF MAX RUBNER[1]

By the late Professor GRAHAM LUSK

CORNELL UNIVERSITY MEDICAL COLLEGE

GREAT men are very rare. They are worth knowing. They give impulse and stimulus to lesser men. They make the world more worth while for others to live in because of their presence in it. Max Rubner was the greatest man I ever knew.

He was born in Munich on June 2, 1854, and died recently in Berlin on April 27, 1932, in his seventy-eighth year. Rubner received his early training under Carl Voit in Munich and here he also came to be intimately associated with Pettenkofer. He spent a year with Carl Ludwig at Leipzig, whom he always held in the highest regard. On the recommendation of Pettenkofer he was appointed to the newly established chair of hygiene at Marburg in 1885, thus becoming full professor in his own right at the age of thirty-one. At Marburg he came in contact with several yourg professors about his own age: Albrecht Kossel, the biochemist; Hans Horst Meyer, the pharmacologist; and Friedrich von Müller, the internist, all of whom became world leaders in their respective subjects. In 1891 he succeeded Robert Koch as professor of hygiene in Berlin and built a new laboratory of hygiene, a building which he retained for his own department when in 1909 he became professor of physiology as successor to Engleman. This position he held for twenty-five years until, at the age of seventy, he was made emeritus.

[1] An address presented before a general session of the American Association for the Advancement of Science at Syracuse, N. Y., June 23, 1932. Dr. Lusk died following a surgical operation on July 18. An obituary notice by Dr. Eugene F. Du Bois was printed in the issue of SCIENCE for August 5.

Though living in retirement during his later years, he continued to write powerful articles, and as one of the secretaries (Planck was the other) of the Prussian Academy of Sciences he frequently presided over its meetings to within a short time before his death.

I have been told that as a young man in Munich he gaily donned the native costume of the Bavarian Tyrol and went forth to walk or climb among the pleasant near-by mountains. Later the rigid formality surrounding a professor in Berlin compelled him to adopt that austerity of formal behavior which the custom of his day required of a man in his position. In the colloquial he behaved *geheimratlich*.

The Isodynamic Law

Rubner entered Voit's Munich laboratory at a time when work was progressing with a calorimeter for the simultaneous measurement of the heat production and the respiratory metabolism of a human being. The work with this apparatus continued for six years but must have been unsatisfactory because it was never published.

In 1878 Rubner carried out some respiration experiments upon rabbits and let them fast until they died. He noticed, after long fasting, when they were thin and had lost almost all their body fat, that the protein metabolism greatly increased so that it alone sufficed to maintain the life functions of the animal. This was the premortal rise in protein metabolism. The work gave him the idea that the calories derived from protein replaced those derived from fat in the maintenance of the life of the animal. Further investigation convinced him that the three great groups of foodstuffs—carbohydrates, fats and proteins—were exchangeable in the body in accordance with their caloric equivalents. This was the isodynamic law of Rubner. This conception did not immediately meet with Voit's approval and its publication was delayed until 1883, which caused a sense of grievance on Rubner's part. It must be remembered that he was twenty-four years old at the time when this work impressed upon him the importance of considering metabolism from the standpoint of energy. His contributions to this point of view are of fundamental importance. Voit never conceded that it was the most valuable method of approach in unraveling the problems of nutrition. So it is especially to Rubner's credit that animal calorimetry occupies the position which it holds to-day.

Before Rubner's time it had been customary to subtract the heat value of urea from the heat value of protein itself in order to calculate the calories which are physiologically available in the organism when protein is destroyed. But Rubner knew that not only urea but many other organic substances, such as creatinine, uric acid, etc., were eliminated in the urine. He therefore oxidized the dried excreta and determined how much heat was liberated by burning an amount of dried urine containing 1 gram of nitrogen. From this and other work he calculated that 1 gram of dry protein yielded in metabolism an average of 4.1 calories, 1 gram of fat 9.3 calories and 1 gram of carbohydrate 4.1 calories. These are Rubner's standard values and have been generally employed throughout the world. During the war they were used to calculate the requirements of nations and to estimate the imports and exports necessary for the proper nutrition of nations.

The Law of Surface Area

The law of surface area belongs to this period of Rubner's career. With the data at hand and using the surface area formula of Meeh, he came to the conclusion that the heat production of mammals was proportional to their surface area. He returned valiantly to the defense of this law in a recent paper presented before the Prussian Academy of Science He there gives the following scheme:

TABLE I

BASIS OF RUBNER'S LAW OF SURFACE AREA

Dogs			Mammals	
Weight	Calories per square meter		Weight	Calories per square meter
kilos			*kilos*	
31.2	1036	Hog	128	1074
24	1112	Man	64	1042
19.8	1207	Dog	15	1039
18.2	1097	Guinea-pig	0.5	1246
9.6	1183	Mouse	0.018	1185
6.5	1153			
3.2	1212			
1:10 Variation	1142 Average		1:7111 Variation	1145 Average

Rubner makes an analysis of the work of F. G. Benedict:

TABLE II

BASAL METABOLISM OF MEN

No. of individuals	Class in weights	Average weights	Calories per sq. m. surface in 24 hrs. (Du Bois)
	kilos	*kilos*	
6	40–50	48.7	922
41	50–60	53.4	914
164	60–70	64.5	927
24	70–80	74.7	924
8	80–90	83.7	924
		Variation 1:1.7	Average 922

Rubner says that in the light of such facts he can not understand how Benedict could have reached a negation of the surface area law.

It is only fair to Benedict to quote from his recently published book on "The Physiology of Reptiles" the opening and closing passages which occur under the heading, "Surface Area Law." The opening passage reads:

> Perhaps no one finding in this entire study has been any more astounding than the definitely shown fact that, with the single exception of the giant tortoises, the heat production of all our cold-blooded animals is extraordinarily uniform when computed on the basis of the calculated surface area, employing the two-thirds power of the weight times a constant.

This affirmation on page 470 is followed by a negation on page 473 which contains this statement:

> It is our intention to analyze in another place the findings of the Nutrition Laboratory on both warm-blooded and cold-blooded animals. . . . It is believed, however, that the apparent relationship between heat production and surface area is wholly fortuitous.

Rubner found that large domestic farm birds, turkey, goose and hen, fall in line with the surface area law of mammals. Small song birds, however, have a higher metabolism. Their breast musculature is very highly developed for the purpose of producing a great volume of song, and this may modify their basal metabolism. "What is the surface area of a bird," Rubner asks? Wings cover highly modified fore extremities and cover part of the body surface, except during flight, when the surface is exposed. Analogies from investigations upon birds are not convincing arguments against the surface area law.

In this latest scientific paper which he sent me last summer Rubner points out that the chemical composition of the dry tissue of fishes, amphibians, reptiles and mammals is almost identical when calculated as free from ash and fat. Thus this tissue in mammals contains 15.1 per cent. nitrogen; in amphibians and reptiles 15.5 per cent.; and in fishes 15.8 per cent. Also the number of gram calories liberated in the combustion of one gram of tissue is nearly the same in all these animals. It therefore appears that there is only one kind of living sustance, which, however, has had its powers modified in different directions in the course of evolution.

When living substance increases in mass, regulating factor concerns the relation between mass and energy production, which factor Rubner calls the law of growth and it is always present in each individual. Except for the high energy metabolism in the early stages of development, this factor follows the law of surface area.

In cold-blooded animals, such as fishes and other aquatic animals, there is a reduction in the energy requirement with every increase in their mass, which fact is comparable with the conditions observed in warm-blooded animals. The relation between mass and energy production can be accounted for only by regulating hormones. Variations in the temperature of living substance has a profound influence on the heat production and closely follows van't Hoff's law on the influence of temperature on chemical reactions. Muscle work may double the energy production. The muscles of fishes have the special function of immediate maximal contractions, even in a cold environment. Possibly fishes may increase the flow of water through their gills during muscular activity, which may endow them with a primitive form of physical regulation of body temperature which combats a rise in their temperature.

If a fish changes into an animal living on land, the energy production is doubled on account of increased muscular exertion. Amphibians and reptiles have a pronounced mechanism for physical regulation in their power to evaporate water, which preserves them from becoming overheated. Benedict indeed has lately shown that this factor may cool a large snake to a temperature below that of its environment.

Rubner thinks that the transition of cold-blooded animals into warm-blooded ones probably takes place through heterothermal types, though there are other possibilities. A characteristic phenomenon is the development of a mechanism of chemical regulation, that is, an increase in heat production in the presence of cold through the union of the heat-producing organs with the brain. Cold on the skin then stimulates the nerve centers which discharge impulses increasing metabolism and maintaining body temperature in the presence of heat loss at the surface. The physical regulation of body temperature takes place in various ways: through varying the distribution of blood at the surface of the body, through sweating or rapid respiration. In birds, in which the muscular effort of flying is very great, loss of heat is promoted by exposure of the body during flight.

Cold-blooded animals like frogs fall into a torpid state during the cold of the winter. With the increase in energy expenditure in the transition from cold-blooded to warm-blooded animals, the mental power expands and life takes on a broader aspect. A warm-blooded animal retains its intelligence at all times, it constantly receives sensations and fills its brain with an untold number of memories, which gives the fundamental background for intellectual work.

Chemical reactions accompany the energy exchange in the living organism. To the morphologist the energy doctrine appears too meager and simple, for it is both formless and colorless, but it has this advan-

tage, that it has been built upon a structure of data which have been determined quantitatively.

At one time Rubner complained that his conception of the "wear and tear" quota of protein metabolism had attracted little attention. The wear and tear quota represents the lowest level of protein metabolism which can be achieved after prolonged administration of a starch-fat diet which is free from protein. However, this fact has been used both in Germany and in America to demonstrate that in many infectious diseases, such as typhoid fever, for example, protein metabolism remains high notwithstanding a starch-cream diet, thus proving a toxic waste of protein in these diseases.

The First Accurate Respiration Calorimeter

Leonardo da Vinci about 1500 wrote, "Motion is the cause of all life." In an address given by Helmholtz in 1869 one reads: "All investigation thus far, respecting the amount of heat which an animal produces when at rest, is in no way at variance with the assumption that this heat exactly corresponds to the equivalent, expressed as work, of the forces of chemical affinity then in action."

We have seen that Rubner became professor of hygiene at Marburg in 1885. In 1889 he had built, largely with his own fine hands, and at a very small actual outlay of money, a self-registering calorimeter, the accuracy of which had been carefully and laboriously checked, and he had demonstrated the age-long problem which Helmholtz had desired to see proved, that the heat production of an animal was exactly that amount which could be calculated from the metabolism data of the period. Thus during 45 days the calorimeter measured 17,349 calories as produced by a dog living in it, whereas 17,406 calories could be computed from the nitrogen in the urine and feces and from the carbon dioxide in the respiration, as being that quantity of heat which should have arisen from the oxidation of materials in the dog's body during the same period of time. The difference between the computed heat and that actually found was only 0.3 per cent.

The most important fact which was hereby established was the proof of the validity of the law of the conservation of energy in the animal body. It followed from this work that no source of energy was available for life except that obtained from the energy of chemical reactions.

In 1892 W. O. Atwater began the construction of a calorimeter for the measurement of the heat production in man, which was first described in 1897. This apparatus, the celebrated Atwater-Rosa calorimeter, demonstrated that the law of the conservation of energy applied also to the human being. It must not be forgotten that Atwater was a pupil in Voit's laboratory when Rubner was assistant there and that he was in frequent touch with Rubner after the latter went to Marburg. Rubner told me that he had personally taught Atwater much that he knew. It is right that the succession of intellectual inheritance should be understood. Recall the names: Lavoisier, Bertholet and La Place, Gay-Lussac, Liebig, Voit, Rubner.

On one occasion Rubner writes concerning growth, "Mute and still, by night and by day, labor goes on in the workshops of life. Here an animal grows, there a plant, and the wonder of it all is not the less in the smallest being than in the largest." And in accord with this expression we find him working with bacteria and yeast cells. The energy doctrine unites the world of living things.

Finally he tells us that though active life is always associated with the utilization of energy, yet no life lasts forever. The energy doctrine teaches that after the completion of an infinitely large number of chemical reactions the labor of life is extinguished. There is one common factor which is shown by a large group of warm-blooded animals—horse, cow, dog, cat, guinea-pig—which is that after reaching maturity an average of about 200,000 calories per kilogram of body substance are expended and then the animal dies. Man, however, has acquired an exceptional position, because during an adult life extending between twenty and eighty years, 775,000 calories per kilogram of body weight are expended before the machine gives way. Rubner believes that recent experiments confirm his results and that length of life, as determined from this standpoint, is a function of evolution and is a contributing factor in the development of the higher animals. The results of this investigation, he says, reveal more clearly to our understanding the secrets of life and death.

Much of what I have said above is taken verbatim from Rubner's own words. I make no apology for doing this. It is right that an American audience should hear and comprehend the voice of a great German master of the science of nutrition.

Personal Memories

The first time I met Rubner I called on him at his laboratory in Berlin and was sent away with an appointment for the next day, a well-known protective device. When I called the following day he took me about his laboratory and I remember the particular pride with which he pointed out the original apparatus with which Helmholtz had made his experiments on sound. At the request of Friedrich von Müller, Rubner wrote an introduction to the German translation (1910) of the second edition of my

"Science of Nutrition," but I never really knew him until he visited me in the United States when he came over to attend the Fifteenth International Congress of Hygiene and Demography, which was held in Washington in 1912. He first visited me in my Adirondack camp, and we gave him a tent in which to sleep. He came provided with a barometer, a hygrometer ("Humidität, hundert Prozent," he would remark as he came to breakfast in the rain) and a pedometer, for he had kept a daily record of the number of steps he had taken for twenty years past in order to write the curve of lessening activity with advancing age. We later learned that he carried a small set of tools in one of his pockets, and when one of our party was slightly injured a first-aid kit appeared from another pocket. He brought his paints with him and went off by himself to paint a picture of St. Regis Lake. He intimated that he had been more comfortable when on a shooting expedition with the Kaiser, and later, when he visited us at our Long Island home, said he could not understand why we should leave it for such a place as the Adirondacks. On Long Island he first tasted lima beans, was delighted with them, and wrote about them on his return to Germany. He had a hobby of collecting old menu cards of dinners, which gave him ideas concerning the changing habits of the diets of the people. I gave a dinner in his honor at the University Club in New York. Nuttall, professor of hygiene at Cambridge, England, who had been his pupil, was seated on my left. He said to him, "I expected to feel like a stranger in America, but I feel nothing of the sort, and when I talk to Lusk it is as though I were back in Munich." He visited the Pacific coast and was surprised and delighted, saying it was finer than Nice where it had been his custom to spend his Easter holidays. He thought the New York Public Library much finer than the Library of Congress in Washington and said our architecture was improving.

Rubner was a tall, well-built man of striking presence. His chief relaxation was attendance at a gathering of artists held regularly on Monday evenings in Berlin. Here, where none of his medical colleagues came, he could find rest for his soul. He sent Mrs. Lusk as a Christmas present a picture he had painted. His eminent pupil, Karl Thomas, told me that Rubner was a man who was very slow to give his confidence to any one, but when he had once given it he never withdrew it and then one could say anything to him. That I also found.

When dining with him once in Berlin I referred to a certain colleague and he replied, "He amounts to nothing. He writes books." I said I was rewriting my own book and asked if he would advise me to stop and he answered, "There are too many books."

He was ruthless in his scientific discussions with Zuntz, but Magnus-Levy, a prominent pupil of Zuntz, has recently written that Rubner's arguments were correct.

A friend said to Rubner, "You should have received the Nobel Prize. You must have stepped on X's toes." "I did," was his only reply. Voit's misunderstanding of him was perhaps due to the fact that the older man did not fully understand the saying of Leonardo da Vinci, "Poor is the pupil who is not greater than his master." Both men rank high in the scale of human achievement in their respective times. Had it not been for this misunderstanding Rubner would have succeeded Voit in physiology at Munich and would have lived there in close companionship with Friedrich von Müller, and undoubtedly Otto Frank, who is a very great physiologist, would have gone to Berlin as the successor of Engleman.

In 1906, when I saw Voit for the last time, I asked him his opinion regarding the theory of the specific dynamic action. The last time I saw Rubner was in the summer of 1930 and I said to him, "Will you not elaborate your statement to me at the International Physiological Congress at Edinburgh in 1923 when you said that the heat production of the specific dynamic action was due to intermediary chemical reactions." He replied, "Nein, es giebt verschiedene Möglichkeiten." In the essentials, however, the presentation of Rubner on the subject in his book, "Die Gesetze des Energieverbrauchs bei der Ernährung," published in 1902, leaves little to be changed. Rubner had the power of arriving at great results through simple means and of drawing correct conclusions from a few well-conducted experiments.

The last visit we made to Rubner was at his home at Pinszwang, a village in the Tyrol just over the Austrian border, a short distance from Füssen, and we thus fulfilled a promise made to him eighteen years before. He was in fine spirits and brought out some excellent wine of which he was very fond. He went with us in the afternoon to Füssen. I can still see his distinguished figure standing at the end of the stone bridge at Füssen as he raised his hat and waved it in farewell.

American Education

Rubner's trip to the United States not only added to the number of his friends here but gave him an insight into conditions which existed in our educational institutions. He wished to attend the last International Physiological Congress held in Boston in 1929, but his physician forbade it. After seeing Karl Thomas he wrote me as follows:

Thomas called upon me immediately after his return from America and brought me good news. I rejoiced over his expression of opinions, which are entirely in accord with my own. In Europe, America is considered exclusively as a land of the dollar. But that is fundamentally false. I have myself seen in what wide circles of society there is no chasing after dollars, and that there is a widespread earnest endeavor in science without thought of money, and that much effort, especially in the young, is dedicated to science in spite of the penurious salaries which are paid.

On July 21, 1930, he wrote me, regretting my decision to retire from active work and then turned again to the subject of the welfare of our teaching profession:

You have still something of importance to accomplish, the improvement in the salaries of professors and the care of professors and their widows in their old age. I am not in favor of luxury, but an existence which is to a certain extent free from care is necessary for our work. In America huge sums are paid to a tenor, to a movie actor, or to a prize fighter. Frederick the Great wished to obtain a distinguished singer for the Berlin opera. The singer demanded a large sum. The King became angry and sent him word that the salary demanded was that which a general received. The singer replied to the King that in future he could get a general to sing for him. Educated men could talk in similar fashion, especially scientists and medical men.

Rubner apparently believed in the old-fashioned definition of *emeritus* as given in the Century dictionary: "In Roman history, a soldier or public functionary, who had served out his time and had retired from service. Such servants were entitled to some remuneration, answering to modern half pay."

PUBLIC SERVICE

At the outbreak of the war in 1914 consultation was held among the scientific men of Germany with regard to the food supply. But their advice was disregarded. In June, 1916, Rubner issued a pamphlet describing how prices of foodstuffs had been enormously increased by middlemen without any regard to the cost of production. He frankly stated that lust for gain had produced conditions which were regardless of the political conditions of the time. His prophetic insight into the situation was disregarded.

Working without assistance in his laboratory, he showed that bran, when left in bread, caused a greater output of nitrogen in the feces than when white bread was taken, and also a larger waste of calories in the feces occurred than after taking the white bread. The nitrogen of the bran was not available for human nutrition and the roughage of bran acted to irritate the digestive apparatus of those with weak stomachs and of old people. Our whole wheat bread faddists have not yet assimilated these to them unwelcome truths.

At the close of the war Rubner was one of those who represented Germany at a conference at Spa. He calculated that the food blockade had cost Germany 800,000 lives and asked that this be taken into consideration when striking the balance in the reparation account. He sent me curves showing the comparable loss in weight of himself and of a prisoner of war. The curves were parallel.

The last letter I had from him was from Berlin, December 14, 1931. It dealt with the present economic situation in Germany, which is so nearly akin to our own that it may be of interest to all of us.

The so-called Necessity-Orders (*Notverordnungen*) have completely changed our internal life. The first discomforts fell upon the public functionaries, who were paid only three times a month and gradually suffered a reduction of 30 to 35 per cent. in their wages. This also reacted severely upon the university professors, whose pay was cut 50 per cent. The middle class is dismissing servants, and every one is seeking smaller and cheaper living quarters.

Those who had lost everything during the time of the inflation and had begun to save are again losing a large part of their property, for industrial investments have fallen to one third of their former value and the state takes in taxes one quarter of the interest of bonds.

The "white collar" class (*Beamtenstand*) is the only one thus affected. There is hesitation to bring about a much more justifiable reduction in the pay of common labor. The price of labor is decreed by the unions and is held high and will be so held, even though it is one of the most important causes of unemployment.

Another factor which appears to me to be necessary is a reduction in the salaries of certain government officials.

There are, however, two most important ways of reducing expenditures: through changes in health insurance and in unemployment insurance. Health insurance has completely failed and leaves every door open for fraud. Since the establishment of health insurance the number of sick has increased threefold, which means that every one can get an illness certificate.

The unemployment insurance is at the moment no better than the health insurance. If every working man were allowed to accept work, even though at a lower wage than formerly, then we would be able to put a large number of workmen into industry. That, however, is impossible because no working man is allowed to accept less than the established wage, and no industry is allowed to pay less than the unions prescribe. To the unemployed and the recipients of charity all social elements must be added, such as the lazy, loafers, thieves, etc., which make between 2 and 3 per cent. of the population of large cities.

Everything which has been set up for the welfare of the working classes has gone to the bad through misuse. One must seek other organizations. I believe that your American arrangement of simple insurance dependent on personal payment is a very good one. Any change with us could be brought about only with great difficulty. But it

must be done in the interest of the working man himself, because the present administration of our form of insurance wastes enormous sums of money.

Of course we have very limited means for scientific investigations, but we still have enough for matters of the highest importance. Our real anxiety is for the future.

I have tried to draw in its varied aspects a picture of a great scientific man. It is happy to think that we may all learn many lessons from the life of such a man as Max Rubner. For the whole of the individual life in health and in disease depends upon the energy metabolism. And the whole of the life of the state, for weal or for woe, depends upon the ability to furnish sufficient calories in food to provide the energy required to maintain the individuals composing the state.

THE TOTAL ECLIPSE OF THE SUN OF AUGUST 31, 1932

By Professor FREDERICK SLOCUM

VAN VLECK OBSERVATORY, WESLEYAN UNIVERSITY

THE total eclipse of the sun of August 31, 1932, will cross New England at the height of the vacation season and will attract not only the professional and amateur astronomers but a throng of others to the path of totality.

This path will be about 100 miles wide, extending down across Hudson Bay, the Province of Quebec and New England. A portion of the path is shown in Fig. 1. The eclipse will be total between the heavy lines. The dotted line marks the center of the path, where the duration of totality will be longest, ranging from 102 seconds north of the St. Lawrence River to 98 seconds on the Maine coast.

The duration of totality diminishes very slowly with the distance from the center line. Ten miles from the center line the duration is only 2 seconds less than the maximum; 20 miles from the center line, 8 seconds less than the maximum. On the northeast shore of Cape Cod the eclipse will be total for 60 seconds; tip of Cape Ann, 70 seconds; Portsmouth, N. H., 85 seconds; Portland, Maine, 92 seconds; summit of Mt. Washington, 99 seconds.

FIG. 1

For the White Mountain region the eclipse will begin at 2:19 P. M., Eastern Standard Time. The total phase will occur at 3:30 P. M. and the eclipse will end at 4:33 P. M. For places north of the mountains the corresponding times will be a few minutes less and south of the mountains a few minutes greater. For Daylight Saving Time add one hour to the above times. The moon's shadow will travel across New England at a rate of about 3,000 feet per second.

From weather observations made especially for the purpose during the past seven years, the probability of clear sky in Quebec and New England, except for the White Mountain region, is about 55 per cent. For the higher mountains it is somewhat less. Even if the forenoon is clear, cumulus clouds may form in the afternoon, with broken masses of sufficient density to obscure the sun. There are so many days of this type in August and September that the scientific expeditions will be widely scattered along the line to distribute the risk of clouds. A partial list of eclipse expeditions, with their locations and leaders, follows, in order of position from NW to SE.

PARTIAL LIST OF ECLIPSE EXPEDITIONS, LOCATIONS AND LEADERS

Parent, P. Q. Royal Observatory, Greenwich, England, Dr. J. Jackson; Dominion Observatory, Ottawa, P. Q., Director R. M. Stewart.

St. Alexis, P. Q. University of Toronto Observatory, Professor C. A. Chant.

St. Lawrence River, P. Q. Paris and Marseilles Observatories, Count A. de la Baume Pluvinel.

Montreal, P. Q. McGill University, Professor A. S. Eve; University of London, Professor A. Fowler.

Magog, P. Q. Solar Physics Observatory, Cambridge University, England, Professor F. J. M. Stratton; Leander McCormick Observatory, University of Virginia, Professor S. A. Mitchell; Royal Astronomical Society, London, Group C.

Derby, Vt. Sproul Observatory, Swarthmore College, Professor J. A. Miller.

North Stratford, N. H. Cincinnati Observatory, Professor E. J. Yowell.

Lancaster, N. H. Mount Wilson Observatory, Pasadena, Director W. S. Adams.

Whitefield, N. H. Seagrave Observatory, Providence, R. I., Director F. E. Seagrave.

Bethlehem or Maplewood, N. H. Adler Planetarium, Chicago, Professor Philip Fox.

Mount Washington, N. H. "Science Service," Washington, D. C., Mr. Watson Davis.

Bartlett, N. H. Tokyo Imperial Observatory, Professor Okuroh Oikawa.

Conway, N. H. Franklin Institute, Philadelphia, Mr. James Stokley.

Center Conway, N. H. Van Vleck Observatory, Wesleyan University, Professor F. Slocum.

North Conway, N. H. Electric Testing Laboratories, New York, Dr. C. H. Sharp.

Fryeburg, Me. Lick Observatory, University of California, Professor J. H. Moore; University of Michigan Observatory, Professor H. D. Curtis; Dearborn Observatory, Northwestern University, Professor O. J. Lee; Georgetown College Observatory, Washington, D. C., Prof. P. A. McNally; Hood College Observatory, Frederick, Md., Professor Leah B. Allen; Goodsell Observatory, Carleton College, Professor E. A. Fath.

Douglass Hill, Me. Perkins Observatory, Ohio Wesleyan University, Professor H. T. Stetson; Warner and Swasey Observatory, Cleveland, Ohio, Professor J. J. Nassau; Royal Astronomical Society, London, Groups A and B.

Sebago Lake, Me. (Region of). Harvard College Observatory, Dr. W. J. Fisher.

South Limington, Me. U. S. Naval Observatory, Captain C. H. J. Keppler.

Biddeford, Me. Deering Observatory, Biddeford, Me., Mr. Frank Deering.

The various expeditions will be working upon one or more of the following problems:

(1) Accurate observation of the times of beginning and end of the eclipse and photographs of the crescent phase of the eclipse for a better determination of the relative position of the sun, moon and earth.

(2) The outline of the corona and the details of its apparent structure. This problem will be attacked by means of photographic telescopes of from 3 to 9 inches diameter and 20 to 80 feet focal length. By means of filters and plates sensitive to various colors, photographs will be taken in blue, yellow and red light.

(3) Chemical composition and physical nature of the chromosphere and corona. Powerful spectrographs will be used during the total phase of the eclipse and especially at the instant of beginning and end of totality.

(4) Light and heat of the corona. The apparent brightness of the corona and its gradation outward from the sun may be measured on the photographic plates, provided they are photometrically standardized. The photoelectric photometer and thermoelectric photometer will be used to measure the total light and heat and the polariscope to study the relative amount of intrinsic and reflected light.

(5) Rotation and internal motions of the corona. This will be studied by the displacement of the lines in the spectrum, by interferometers and by the comparison of photographs taken at different places and at different times.

(6) The appearance and motions of the "shadow bands" which appear just before the beginning and just after the end of the total eclipse.

(7) The effects upon terrestrial magnetism by the eclipse.

(8) Meteorological changes during the passage of the moon's shadow.

(9) Effects of the eclipse upon radio transmission.

(10) Psychological effects upon animals and human beings.

In order that the astronomers may have accurate time the U. S. Naval Observatory will send out special signals by radio from 1:55 to 2:00 P. M. and from 3:55 to 4:00 P. M., Eastern Standard Time, on August 31. These signals will be rebroadcast by Station WGY, Schenectady, and by Station WCSH, Portland, Maine, for those who are not equipped to receive the Arlington signals. WGY uses a frequency of 790 and WCSH of 940 kilocycles.

For the benefit of the general public special road maps, showing the region of the total eclipse, have been issued by the Socony Co., The New England Hotel Association, and the Publicity Bureaus of Maine, New Hampshire and Vermont. Eclipse folders giving data in regard to special trains, excursions, etc., have been put out by the New York, New Haven and Hartford and by the Boston and Maine railroads. Several auto bus companies have also announced their schedules for excursions to the eclipse area.

Local officials, Chambers of Commerce, etc., will cooperate with the transportation companies in finding suitable places from which the public may view the eclipse. Such places will, of course, not be near the camps of the scientific expeditions. The astronomers will require silence and freedom from annoyance of any kind in order to carry out their programs successfully in the few precious seconds that will be available.

OBITUARY

LOUIS WINSLOW AUSTIN

DR. LOUIS WINSLOW AUSTIN, a member of the staff of the National Bureau of Standards and an international authority on radio transmission, died in Washington on June 27, 1932, following a serious operation. He had been in poor health for some time.

Dr. Austin was born on October 30, 1867, in Orwell, Vermont, not far from Middlebury College, where he graduated in 1889. During the next four years he studied at Clark and at the University of Strasburg, where he received his doctorate. In 1893 he went to Wisconsin as a member of the physics staff of the university, and there he met Miss Laura A. Osborne, of La Crosse, whom he married in 1898.

Impressed with the spirit of German research, Dr. Austin returned to Germany in 1902, where he spent two years as a member of the staff of the Physikalisch-Technische Reichsanstalt at Charlottenburg. During these earlier years his interests were catholic, and his published papers of this period include a wide variety of subjects; but after 1904, when he was called to the Bureau of Standards, he devoted his energies almost wholly to a long series of radio researches, which brought him international recognition. From 1908 to 1923 he was in charge of the naval radio-telegraphic research laboratory at the Bureau of Standards, affording him unusual opportunities for long-range experiments. In collaboration with Dr. Louis Cohen he determined experimentally the relationship between the strength of transmitted and of received signals for distances up to 1,000 miles at sea, which formed the basis for the Austin-Cohen formula, now widely used in determining the service areas of transmitting stations. In recent years his work was confined largely to a study of the causes of vagaries in the strength of radio signals, a subject which had fascinated him from the beginning.

Dr. Austin was chairman of the American section of the International Scientific Radio Union and past president of the Institute of Radio Engineers. The medal of the institute was awarded him in 1927. Middlebury College conferred upon him the honorary degree of doctor of science in 1920. His confrères the world over recently bestowed upon him the greatest honor at their command by nominating him unanimously for the presidency of the International Scientific Radio Union.

Dr. Austin's gentle kindliness will linger in the memory of all who knew him. He was warm-hearted, modest, quiet, beloved by his friends. His devotion to his work speaks for itself in a last treasured note: "I am going into the hospital tomorrow, and if things should go wrong, I most earnestly beg of you to see to it that the Bureau continues my signal measurement work, at least until such a time as all workers are agreed that other observations such as those on Kennelly-Heaviside heights can take the place of signal intensity measurements for correlation purposes."

His work is going on.

LYMAN J. BRIGGS

DR. HERMANN VON WECHLINGER SCHULTE

1876–1932

DR. HERMANN VON WECHLINGER SCHULTE, professor of anatomy, and dean of the Creighton University School of Medicine, died at the age of fifty-five years on July 13 in Omaha, Nebraska. Dr. Schulte, the only child of an Episcopal clergyman, was born in Utica, New York, on August 9, 1876. He was educated at Trinity College, Connecticut, where he received his A.B. degree in 1897. Possessing a splendid training in the classical studies, he was eminently fitted to follow his father's course in the ministry, but chose instead a career in medicine. He was graduated with high honors as doctor of medicine at Columbia University in 1902. After his interneship he, under the able and inspiring leadership of Dr. G. S. Huntington, taught anatomy and did brilliant research at Columbia from 1904–17. The older anatomists well remember the chivalry and intellectual perspicuity displayed by Dr. Schulte during his discussion of anatomical papers at the yearly meetings of the American Association of Anatomists.

In 1917, Dr. Schulte accepted the professorship of anatomy at Creighton University. Two years later he was appointed dean of the medical school. It was at Creighton University that Dr. Schulte demonstrated his leadership in medical education. By example and exhortation, he imparted to the minds of students, graduates and faculty members the conviction that the justification and purpose of a medical school was not only its artistry and science but primarily its service and benefit to the community. Much as he relished anatomic research, he purposely caused it to be supervened by research in the social sciences because he felt that they could most effectively give to the medical profession its necessary sociologic consciousness and adjust it to the ever-changing conditions of practice.

Because of his exceptional mastery of all branches of anatomy, Dr. Schulte's didactic lectures were highly informative, inspirational and provocative to independent thinking and study. As dean, Dr. Schulte excelled in pedagogy and psychology. He

loved students and was loved by them, for he believed in youth, despite its present veneer of cynicism and sophistication.

Dr. Schulte's scientific achievements in anatomical research, much of which was linked with the American Museum of Natural History, constitute outstanding contributions in the annals of American anatomy. His publications comprise such diverse subjects as the anatomy of whales, the lumbar vertebrae of Scutisorex, the venous system of marsupials and monotremes, the development of the neuraxis, fusion of cardiac anlages and formation of the cardiac loop, the development of the great veins and the hepatic circulation in the cat and the histogenesis of the salivary glands. His largest work is a monograph on the anatomy of the Sei whale (*Balaenoptera borealis*), a foetus specimen of which was taken by Roy C. Andrews at Aikawa, Japan, in 1910.

As a man of letters, Dr. Schulte was preeminently a philosopher and as such was highly honored in his community. In his passing medical education has lost an efficient leader, while philosophy has been deprived of a mind that should have recorded its struggles and triumphs and its ingenious welding of human adversities.

NICHOLAS A. MICHELS

RECENT DEATHS

DR. J. PAUL GOODE, professor emeritus of geography at the University of Chicago, died on August 5, in his seventieth year.

MISS CAROLYN GESLER, assistant at the Yale Observatory since 1923, was killed in an automobile accident in Alabama on July 26.

SIR WILLIAM WILLCOCKS, British engineer, projector and designer of the Egyptian Assouan Dam, died on June 28, at the age of eighty years.

M. ALBERTO SANTOS-DUMONT, the aeronautical inventor and pioneer, died at São Paulo on July 23, at the age of fifty-nine years.

DR. FRAN JESENKO, professor of botany at the University of Ljubljana, Jugo-Slavia, died in an Alpine accident on July 14. He was fifty-seven years old.

SCIENTIFIC EVENTS

THE VIENNA ACADEMY OF SCIENCES

AT meetings of the Vienna Academy of Sciences held on May 30 and 31, according to a report in *Nature*, Dr. Hans Molisch, emeritus professor of plant anatomy and physiology in the University of Vienna, was elected a vice-president, and Dr. Anton Eiselsberg, emeritus professor of surgery in the University of Vienna, was made an honorary member. In addition to various Austrian members, the following foreign elections were made: Dr. Franz Kossmat, professor of geology in the University of Leipzig; Dr. E. B. Wilson, professor of biology at Columbia University; Dr. Michael Rostovtzeff, professor of ancient history and classical archeology at Yale University; Dr. Hugo Obermaier, professor of ancient history at the University of Madrid, and Dr. Norbert Krebs, professor of geography at the University of Berlin, to be corresponding foreign members; and Dr. Friedrich Meinecke, professor of history at the University of Berlin; Dr. Eduard Schwartz, professor of classical philology at the University of Munich, and Dr. Jakob Wackernagel, professor of classical philology at the University of Basle, to be honorary foreign members. The following awards of prizes were also announced: The Ignaz L. Lieben prize, jointly to Dr. Georg Koller for his work on the acids of lichens and Dr. Alois Zincke for his researches on perylene; the Haitinger prize to Dr. Otto Redlich for his investigations on the constitution of water and aqueous solutions; the Hansgirg prize to Dr. Hans Krumpholz for his determinations of the positions of double stars and comets; the Rudolph Wegscheider prize to Dr. Fritz Wessely for his work on glucosides, flavones and natural coumarins; and the Fritz Pregl prize to Dr. Moriz Niessner for his micro-analytical investigations on alloys.

THE JOURNAL OF CHEMICAL PHYSICS

As a part of its comprehensive program of physics publications, the recently formed American Institute of Physics has announced that it will shortly commence a new publication to be called the *Journal of Chemical Physics*.

The journal will be edited by Professor Harold C. Urey, of Columbia University, who is at present forming a group of associate editors to assist in reviewing contributed manuscripts. Among those who have allied themselves with Dr. Urey are Dr. Donald H. Andrews, of the Johns Hopkins University; Dr. E. U. Condon, of Princeton University; Dr. Wheeler P. Davey, of the Pennsylvania State College; Dr. David M. Dennison, of the University of Michigan; Dr. Karl F. Herzfeld, of the Johns Hopkins University; Dr. T. R. Hogness, of the University of Chicago; Dr. Eric R. Jette, of Columbia University; Dr. Frederick G. Keyes, of the Massachusetts Institute of Technology; Dr. G. B. Kistiakowsky, of Harvard University; Dr. E. O. Kraemer of E. I. du Pont de

Nemours & Company; Dr. Charles H. Kunsman, of the Fixed Nitrogen Research Laboratory; Dr. Victor K. LaMer, of Columbia University; Dr. Allen C. G. Mitchell, of New York University; Dr. Charles P. Smyth, of Princeton University, and Dr. Hugh S. Taylor, of Princeton University. Several others will be added to this list and it is also planned to form an advisory council composed of several eminent physicists and chemists to review the general editorial policies to be followed.

It is expected that plans for the Journal can be completed and manuscripts can be received and selected in time for the first issue to appear in January, 1933.

Primary among the circumstances which have led the Institute of Physics to undertake the new publication is the increasing number of articles in physical chemistry which have distinct emphasis on the physics side. These have not found a suitable outlet in any journal now in existence being perhaps too mathematical for the *Journal of Physical Chemistry*, too physical for the *Journal of the American Chemical Society*, or too chemical for *The Physical Review*. While these journals have gone out of their way, at the risk of displeasing many readers, to provide outlets for such papers, the net result has been that the latter did not find their proper audience because no single journal existed in which the field could be concentrated. The institute, in answer to inquiries, received a great many letters from physical chemists and others endorsing the proposal to establish a journal suitable for such a purpose. Incidentally, it is understood that the older outlets for papers in the field may be somewhat curtailed in the near future. If such is the case, the new journal will in part maintain the opportunities for publication.

The American Institute of Physics, Incorporated, is a membership corporation of which the members are five national societies: The American Physical Society, The Optical Society of America, The Acoustical Society of America, The Society of Rheology, and The American Association of Physics Teachers. It is controlled by a governing board to which each society elects three members. Primary among its objects is the publication of journals. In its capacity as cooperative publishing agent for the founder Societies it now publishes *The Physical Review, Reviews of Modern Physics, Physics, Journal of the Optical Society, The Review of Scientific Instruments, Journal of the Acoustical Society of America* and the *Journal of Rheology. The Journal of Chemical Physics* will fall naturally into this comprehensive program.

The business management of all of the journals of the institute is in charge of Dr. Henry A. Barton, director, and Dr. John T. Tate, adviser on publications. Inquiries or suggestions concerning the new journal would be welcomed and may be addressed either to Dr. Harold C. Urey, Department of Chemistry, Columbia University, or to the American Institute of Physics, 11 East 38th Street, New York, New York.

THE JOURNAL OF PARASITOLOGY

DR. HENRY B. WARD, who for eighteen years has been the owner and managing editor of the *Journal of Parasitology*, has given this journal to the American Society of Parasitologists. The journal will be published by this society as its official organ. The editing and management has been delegated to an editorial committee consisting of W. W. Cort, *chairman*, R. W. Hegner and F. M. Root, appointed for a period of five years, who will be assisted by a rotating editorial board representing the different phases of parasitology and the different geographical areas represented in the membership of the society. The first number published under the society's control will be volume nineteen, number one (September, 1932).

The American Society of Parasitologists receives through Dr. Ward's generous gift a well-established journal which he has built up almost entirely through his own efforts. Established in September, 1914, the *Journal of Parasitology* has, during the eighteen volumes published under Dr. Ward's editorship, been the only journal devoted exclusively to the field of parasitology in the Western Hemisphere. From the very first in spite of financial difficulties it has been published without interruption and has always reflected the high scientific idea of its editor. The *Journal of Parasitology* immediately took its place as one of the leading journals in the world in its subject, and has been an important factor in the rapid development of the subject of parasitology in the United States during the last two decades.

W. W. CORT

THE INTERNATIONAL ELECTRICAL CONGRESS

MORE than three hundred reports and papers on electrical and related subjects were presented before the 13 sections of the International Electrical Congress held in Paris from July 5 to 12, according to the report of Dr. A. E. Kennelly, chairman of the American delegation, to Dr. Clayton H. Sharpe, president of the U. S. National Committee of the International Electrotechnical Commission.

Papers presented at the Congress by American authors included:

"The Search for Better Ferro-magnetic Materials," by T. D. Yensen.

"Development of Electrical Machinery in the U. S.," by P. L. Alger and F. D. Newbury.

"Production and Transformation of Electrical Energy in the U. S.," by F. A. Allner, A. D. Bailley, A. G. Christie and F. C. Hanker.

"Evolution and Development of Railway Electrification in the U. S.," by E. L. Moreland.

"World-wide Telephony, its Problems and Future," by F. B. Jewett and B. Gherardi.

The American delegation included, in addition to Dr. Kennelly, Dean Harold Pender, secretary, Dr. H. L. Curtis, Dr. V. Karapetoff, Mr. A. S. Garfield and Mr. H. E. Shreeve. Dr. Kennelly, who is professor emeritus of electrical engineering at Harvard University, was appointed by the Committee of Organization as the American vice-president of the congress. Over 30 nations were represented with more than 1,300 individual members in attendance. No official actions were taken.

The transactions of the congress, to be published in fourteen or fifteen volumes of about 8,000 pages in all, are expected to be ready for distribution about November 1.

THE NEW YORK DINNER FOR DELEGATES TO THE GENETICS AND EUGENICS CONGRESSES

ON the evening of Tuesday, August 23, there will be held at the Waldorf-Astoria Hotel in New York City a dinner in honor of the foreign delegates to the Sixth International Genetics Congress, which will begin its session at Cornell University the next day, and to those of the Third International Congress of Eugenics, which will have just concluded its sessions in New York City. Previous to the dinner the delegates and their friends will inspect the hotel as guests of its management. There will be a brief speaking program after the dinner, and at its conclusion those who are to attend the Genetics Congress will board the special train for Ithaca.

It is hoped that a large number of American biologists will attend this dinner and help to welcome our distinguished guests. The dinner will be a complimentary one to all foreign delegates through the generosity of the Carnegie Endowment for International Peace. Others may purchase tickets, at $4.00 per plate, from the treasurer of the congress at its headquarters at John Jay Hall, Columbia University, after August 19, or from the undersigned.

E. W. SINNOTT,
Chairman Dinner Committee
BARNARD COLLEGE,
COLUMBIA UNIVERSITY

OFFICERS OF THE NATIONAL RESEARCH COUNCIL

ANNOUNCEMENT is made of the election of the following officers of the National Research Council for the year 1932–33:

Chairman, William H. Howell, director emeritus and professor emeritus of physiology, School of Hygiene and Public Health, the Johns Hopkins University.

First Vice-chairman, David White, vice-president, National Academy of Sciences; principal geologist, U. S. Geological Survey.

Second Vice-chairman, Simon Flexner, director, Rockefeller Institute for Medical Research.

Third Vice-chairman, John J. Carty, Winter Park, Florida.

Chairmen of the Divisions of General Relations:

Federal Relations, George Otis Smith, chairman, Federal Power Commission.

Foreign Relations, R. A. Millikan, director, Norman Bridge Laboratory of Physics, and chairman of the Executive Council, California Institute of Technology.

States Relations, Raymond A. Pearson, president, University of Maryland.

Educational Relations, S. P. Capen, chancellor, University of Buffalo.

Chairmen of the Divisions of Science and Technology:

Physical Sciences, F. K. Richtmyer, professor of physics, and dean of the Graduate School, Cornell University.

Engineering and Industrial Research, Dugald C. Jackson, professor of electrical power production and distribution, Massachusetts Institute of Technology.

Chemistry and Chemical Technology, Charles A. Kraus, research professor of chemistry, Brown University.

Geology and Geography, W. H. Twenhofel, professor of geology, University of Wisconsin.

Medical Sciences, Stanhope Bayne-Jones, professor of bacteriology, School of Medicine and Dentistry, University of Rochester.

Biology and Agriculture, Fernandus Payne, professor of zoology, Indiana University.

Anthropology and Psychology, A. T. Poffenberger, professor of psychology, Columbia University.

Dr. George E. Hale, honorary director of the Mount Wilson Observatory, continues as honorary chairman of the council, and Dr. Vernon Kellogg, for twelve years the permanent secretary of the council, is retained as secretary emeritus.

SCIENTIFIC NOTES AND NEWS

THE presidential address before the Sixth International Congress of Genetics will be given by Professor T. H. Morgan, director of the Kirchhoff Laboratory of the Biological Sciences of the California Institute of Technology, on the evening of Thursday, August 25. The congress meets at Ithaca, from August 24 to 31.

DR. CHAS. B. DAVENPORT, director of the Station for Experimental Evolution of the Carnegie Institution of Washington, will preside over the International Congress of Eugenics, which meets at the American Museum of Natural History from August 21 to August 23. Dr. Henry Fairfield Osborn, president of the American Museum of Natural History, who with Major Leonard Darwin is honorary president, will give an address at the general assembly on "Birth Selection *versus* Birth Control."

AT the close of the meeting of the International Entomological Congress in Paris Dr. Ignacio Bolivar, director of the Spanish National Museum of Natural Sciences and director of the Botanical Garden, Madrid, was elected president. The next congress will meet in Madrid in 1935.

DR. WILLIAM H. HOWELL, who recently retired from the directorship of the Johns Hopkins School of Hygiene and Public Health, and who is now chairman of the National Research Council and of the Executive Committee of Science Service, has left for Europe. He will attend the International Physiological Congress, which opens in Rome on August 29. Dr. Howell was president of the congress when it met in Boston three years ago. Professor Filippo Bottazzi, of the University of Naples, is president of the congress at Rome.

DR. J. MCKEEN CATTELL, editor of SCIENCE, left New York for Copenhagen on August 11 to attend the International Congress of Psychology, of which he is the retiring president. He returns from Hamburg on August 25. Professor Harold Höffding, who, born in 1843, was one of the founders of modern psychology, has died since his election at New Haven three years ago to the presidency of the congress.

DR. ROBERT A. MILLIKAN, director of the Norman Bridge Laboratory of the California Institute of Technology, will go to Ellendale, North Dakota, on August 23 for a three-day study of currents, temperatures and other air phenomena at the United States Aerological Station. Dr. Millikan will cooperate with Thomas Lawlor, director of the station.

ONE hundred and twenty-three graduates, students, colleagues and friends of Professor John Weinzirl, of the department of bacteriology of the University of Washington, recently tendered a banquet to him at the Meany Hotel in Seattle. The occasion was the celebration of twenty-five years of service to the University of Washington. A program, consisting of congratulatory addresses and the presentation of a number of gifts, including among others a movie film of the bacteriology department and a volume of letters of appreciation, was carried out.

THE Cross of a Chevalier of the Order of the Crown of Italy has been conferred on Dr. Louis D. Moorhead, dean and professor of surgery at the Loyola University School of Medicine, Chicago.

AUSTIN H. CLARK has been elected vice-chairman of the American Geophysical Union of the National Research Council. He is also chairman of the editorial and publications committee and during the past three years has been chairman of the section of oceanography. Mr. Clark also has been elected a member of the International Committee on Radio.

THE following officers have been elected by the British Institution of Electrical Engineers for the year 1932–33, to take office on September 30: *President,* Professor E. W. Marchant; *Vice-President,* H. T. Young; *Hon. Treasurer,* Mr. P. Rosling; *Ordinary Members of the Council,* Professor J. K. Catterson-Smith, A. P. M. Fleming, H. W. H. Richards and W. S. Burge.

IT is proposed, according to *Nature,* to appoint a syndicate at the University of Cambridge, consisting of the vice-chancellor, Dr. E. D. Adrian, the university treasurer, Professor R. H. Fowler, Mr. F. T. Brooks and Mr. R. E. Priestley, to consider the organization of the research institutes in the university and their relations to the university and its departments, and to report to the university by the end of the Lent Term, 1933.

THE Royal Society, London, announces that Mr. C. N. Hinshelwood, Trinity College, Oxford, and Dr. M. L. E. Oliphant, Trinity College, Cambridge, have been appointed Messel Research Fellows. Dr. W. Hume-Rothery, Magdalen College, Oxford, and Dr. A. J. Bradley, University of Manchester, have been appointed Warren Research Fellows.

GEORGE W. LITTLEHALES, head of the division of research of the Hydrographic Office of the Navy, has been retired from active duty under the provisions of the economy bill after forty-seven years of service. He had been retained temporarily for one month after July 1.

AFTER thirty-seven years of association with the Armour Institute of Technology in Chicago, ten years

of which he served as president, Dr. Howard Monroe Raymond recently retired because of ill health. Dr. Raymond was elected president emeritus by the board of trustees.

THE REV. J. P. ROWLAND, S.J., has been appointed director of Stonyhurst College Observatory, England, to succeed the Reverend E. D. O'Connor, S.J., who has become rector of the college.

DR. T. W. M. CAMERON, lecturer in helminthology at the University of Edinburgh, has been appointed to the newly created chair of helminthology at McGill University, Montreal, and to the directorship of the Institute of Parasitology at Macdonald College, the agricultural faculty of the university.

DR. D. T. HARRIS, since 1921 assistant professor in the Institute of Physiology at University College, London, has been appointed professor of physiology (London Hospital Medical College) as from October 1.

DR. ALBERTA GRAFF MARIN, who took his doctor's degree in plant pathology at Cornell University in 1931, is now chief of the "Servicio de Sanidad Vegetal" for the Republic of Chile. Dr. Graff is thus in charge of all the federal plant quarantine inspection and regulatory work. He has also been appointed professor of plant pathology at the National University at Santiago.

THE following have been awarded J. J. Storrow Fellowships for 1932–33 in the Division of Geology and Geography, National Research Council: Kenneth K. Welker, studies in mining geology at Harvard University; Robert R. Coats, studies in economic geology at the University of Washington; Chester B. Claypool, studies in paleontology at the University of Illinois; Charles B. Hitchcock, studies in geography at Columbia University; Oscar Haught, studies in paleobotany at West Virginia University; Cornelius G. Dahm, studies in seismology at St. Louis University. Arthur Keith, *chairman* of the committee on fellowships, who sends this information, writes: "The number of candidates for fellowships this year was much larger than in previous years, sixty-nine having applied, and the papers filed showed that the applicants were of high general caliber. These facts show the great need for fuller means of helping capable young men through the early stage of research in geology and geography."

MISS MARY E. BATEMAN, of Albany, New York, has been appointed as the research fellow of the National Tuberculosis Association for the academic year 1932–33.

DUE to his work with the Compton-Stearns-Bennett party, investigating cosmic ray effects in Colorado altitudes last year, Wilcox P. Overbeck, Denver University student, has received a grant from the Massachusetts Institute of Technology which will enable him to enroll in that institution in September.

DR. BERNARD F. MCGRATH, dean of the Marquette University School of Medicine, is spending the summer in Europe and is engaged in studying traumatic surgery in various foreign medical centers, particularly in Vienna. While abroad he also expects to plan for the new building of the Marquette Medical School, which will be opened for classes in September.

DR. FRANK WALTER WEYMOUTH, professor of physiology at Stanford University, is continuing work begun for the U. S. Bureau of Fisheries last year, and during this summer will be in charge of the shrimp investigation on the South Atlantic and Gulf coasts, with headquarters in New Orleans.

PROFESSOR VLADIMIR KARAPETOFF, of the College of Electrical Engineering of Cornell University, attended the International Congress of Electricity in Paris, France, which was held from July 5 to 12, as Cornell's official delegate. He will sail for the United States in August after visits to Germany and Switzerland.

RICHARD ARCHBOLD, research associate in the department of mammals, American Museum, is spending the summer in Europe where he is visiting leading museums to study mammal material from Madagascar and the Celebes. In Berlin he will work upon a collection of mammals from the Celebes in collaboration with Dr. Ernst Schwarz of the Berlin Museum.

C. T. ELVEY and T. G. MEHLIN, of the Yerkes Observatory, with a camping outfit and instruments from both the Yerkes and Mount Wilson Observatories, are spending the summer in the Davis Mountains of west Texas to determine the most suitable site for the new astronomical observatory for the University of Texas, for which $1,000,000 was provided by the will of the late William McDonald, banker, of Paris, Texas.

THE Chesapeake Biological Laboratory at Solomon's Island, Maryland, was dedicated on July 19. This laboratory has been constructed under the auspices of the Maryland State Conservation Commission for the purpose of economic and other studies in the marine life of Chesapeake Bay. The building was dedicated by the Honorable Albert C. Ritchie, Governor of Maryland, with an address by Dr. James G. Needham, of Cornell University.

WITH a total registration of 180, the summer meeting of the Corn Belt Section of the American Society of Agronomy and American Society of Plant Physiologists was held at the University of Wisconsin, on July 11, 12 and 13. The program was an exposition

of the laboratory and field research on plants in progress at the College of Agriculture.

THE ninth International Congress of the History of Medicine will be held at Bucharest under the presidency of Dr. V. Gomoiu from September 10 to 18. The principal subjects for discussion will be the evolution of medicine in the Balkan countries and the protection of Europe against plague, as well as a number of miscellaneous subjects, such as Goethe and medicine, by Professor Diepgen, of Berlin; Robert Boyle and Polydore Vergil, by Professor John F. Fulton, Yale University, and Chaucer and medieval medicine, by Dr. J. D. Rolleston, who has been appointed the British representative at the congress and delegate of the Royal Society of Medicine.

ACCORDING to the *British Medical Journal* the eighth international conference organized by the International Union against Tuberculosis will be held at The Hague and Amsterdam from September 7 to 9, 1932, under the chairmanship of Professor Nolen. The following subjects have been selected for discussion: (1) relation between allergy and immunity, opening report by Professor Jules Bordet (Belgium); (2) gold therapy, opening report by Professor Sayé (Spain); and (3) aftercare schemes for the tuberculous, opening report by Dr. Vos (Netherlands). According to a custom which has become established, the Netherlands Association against Tuberculosis will organize a study trip for members of the conference.

THROUGH the cooperation of the University of California and the U. S. Department of Agriculture, a sugar beet testing laboratory has been set up at the branch of the College of Agriculture in Davis. The equipment is to be used for testing samples to expedite the experimental work of the department and of the College of Agriculture.

MME. MARIE SKLODOWSKA-CURIE, of the Radium Institute, Paris, has announced that she has been enabled through the gifts of scientific friends to establish a similar institute at Varsovie.

ACCORDING to *Nature*, on June 1 the Governor-General of the Union of South Africa, the Earl of Clarendon, opened the reconstructed South African Museum in Cape Town, and so marked the accomplishment of an instalment of the development scheme of the trustees. The museum, founded as a Cape Government institution in 1885, was housed in a new building in 1897, but had seriously outgrown the accommodation there. The present additions permit of a running sequence in the exhibits of different sections, and have given new opportunities for the proper display of some of the exhibits. The additions, on two stories, consist of the old Art Gallery and an entirely new block on the opposite side, forming two large halls, 90 feet long by about 35 feet wide. The lower of these is devoted to ethnology, and here life-casts of native races have found a fitting place; the upper contains the big-game collection, and the opening is marked by the addition of a new group of springbok. The trustees and Dr. Leonard Gill have made a notable contribution to museum progress in the Union.

THE board of trustees of Western Reserve University has accepted a grant of twenty-five thousand dollars from the Rockefeller Foundation, who have contributed frequently to the investigations of diseases caused by filtrable viruses, to be used for a scientific study of whooping cough in the department of medicine of the Medical School, in cooperation with Lakeside Hospital. The study, which is well under way, will be conducted by Dr. Gerald S. Shibley, associate professor of medicine, and is planned to cover a four-year period. Dr. James Angus Doull, professor of hygiene and public health of the School of Medicine, will cooperate in the work.

DISCUSSION

DORMANCY IN TILIA SEEDS

BASSWOOD (*Tilia*) has many excellent qualities which make it one of the valuable timber trees of the eastern United States. The seeds normally have a germinative capacity of 80 to 90 per cent., but give little or no germination in the seedbed. Under natural forest conditions germination of the crop of any seed year is distributed over many seasons with the result that a high percentage of viable seed is destroyed by parasites.

The causes of this profound dormancy have been discussed recently by a number of authors. The studies here reported (involving experiments with some thirty-five thousand seeds of eleven separate collections) lead to conclusions at variance with those of other investigators.

The following views as to the primary causes of dormancy in *Tilia* seeds have been set forth. Rose (1919):[1] "The results obtained show that the dormancy exhibited by seeds of *Tilia* is not due to any property of the seed coat, although that structure may serve to lengthen the dormant period, but is to be ascribed to conditions obtaining within the endosperm or the embryo or both." Crocker (1925)[2]: "Many

[1] R. C. Rose, *Bot. Gaz.*, 67, 295.
[2] Wm. Crocker, *Jour. N. Y. Bot. Garden*, 26, 181.

seeds are like the rose in having dormant embryos and in requiring a low temperature period in a germinator for after-ripening. This is true of basswood, Juniper, fall-seeding maples . ." Chittenden (1926)[3]: "The difficulty seems to be due to the impervious seed coat and rudimentary embryo." Grimsley (1930)[4]: "Seed coats at no time appear to be a limiting factor in the absorption of water. Dormancy in *Tilia* seeds exists in the embryo or in the endosperm, probably in both." There is nothing in these papers to indicate that the authors attempted to germinate naked embryos.

The writer finds that embryos of un-after-ripened seed exhibit geotropic curvature within twenty-four hours and at least one millimeter elongation of the hypocotyl within forty-eight hours when placed on a moist substratum at room temperature. These results occur whether the embryo is entirely freed of the enveloping endosperm or merely freed at the tip by dissecting away a small portion of the endosperm.

From experimental evidence the writer concludes that the effect of the nucellar membrane on oxygen intake is an important factor in the dormancy of *Tilia*. Apparently, one of the after-ripening changes is increased permeability, whereby the seed is enabled to germinate under ordinary oxygen pressure. This change takes place readily in moist stratification at refrigeration temperatures, but in some instances it occurs also in air dry storage at room temperature.

Impermeability of the testa to moisture is a factor in prolonging the dormancy of *Tilia*. Under natural conditions it may be responsible for delaying germination several years. Such impermeability may be overcome by treating seeds, freed of their pericarps, with concentrated sulphuric acid. When so treated fresh seeds or seeds from air dry storage after-ripen perfectly and germinate over a wide range of refrigeration temperatures.

J. NELSON SPAETH

YALE FOREST SCHOOL,
NEW HAVEN, CONN.

ORIGIN OF A TETRAPLOID SHOOT FROM THE REGION OF A TUMOR ON TOMATO

IT has been known for some time that polyploid cells occurred frequently in the tumorous tissues of plants infected with *Bacteria tumefaciens*. Such conditions suggested the possibility of obtaining from these areas shoots whose chromosomal constitution would be changed should they arise from polyploid cells initiated under the influence of the bacterial parasite. In order to test this 120 tomato plants were inoculated internodally in the spring of 1931 with cultures of *Bacteria tumefaciens*. One hundred nine of these inoculations were successful and tumors were formed. When the tumors reached the size of a pea the stems were cut off about 3 to 5 centimeters above them to induce shoot formation. In many cases shoots originated from the tissue about the tumors; in 7 instances a shoot formed from the region where the tumor was developing. These seven shoots, together with a small portion of the stem and the tumor, were removed and the stem, tumor and lower part of the shoot buried in soil to induce rooting. Two of the seven shoots died. One of the five successfully rooted proved to be tetraploid. All the roots coming from this shoot three centimeters and more above the point of origin from the tumorous stem were examined and showed 48 somatic chromosomes as compared with the 24 somatic chromosomes of the plant from which it originated. Two months after rooting this shoot was separated from the tumorous stem and transplanted. The resultant plant had leaves the same size and general appearance as the stem plant, but the flowers were a little larger.

This is another instance which would seem to show that polyploidy can not be treated as a cause for the tumorous growths, as sometimes suggested, but may be a harmless sequence of the conditions initiated in the tumorous region. Explanations of the manner in which such polyploidy may be effected have been considered in earlier studies of the protoplasmic state under similar conditions.

The present method and the results obtained might prove useful in attempts to experimentally bring about an increasing occurrence of polyploidy and the production of plants with altered chromosomal constitution. Cutting itself has given rise to polyploidy in shoots arising from the callus tissue; in this instance, however, the shoot originated well outside of any region of injury. The slight injury at the inoculation point was on the opposite side of the stem and the removal of the upper portions of the stem was purposefully well above the tumorous region.

DONTCHO KOSTOFF

DEPARTMENT OF GENETICS,
ACADEMY OF SCIENCES,
LENINGRAD, RUSSIA

JAMES KENDALL

DEPARTMENT OF BIOLOGY,
COLLEGE OF THE CITY OF NEW YORK

[3] A. K. Chittenden, *38th Ann. Rpt. Mich. Agr. Expt. Sta.*, 293.

[4] G. Grimsley, *Jour. Elisha Mitchell Sci. Soc.*, 46, 73.

PHOTO-PRINTING

IN the issue of SCIENCE for May 6 appeared an article by Professor Tracy I. Storer, of the University of California, on "What is a Publication?" Professor Storer discussed a definition of "publication"

as given by Dr. C. W. Stiles and described briefly several duplicating methods other than regular type which are of sufficient character to dignify the product as "a publication." In this discussion, he did not mention the process of photo-printing as such, although it is an important process, and some of his examples which he called "mimeographing" may have been reproduced by that method.

Photo-printing has for some time been developed commercially in connection with lithography and has been used in our factory for several years, particularly in the duplication of instruction sheets and pamphlets for scientific apparatus. In flexibility and appearance, it approaches type printing and for small runs from 100 to 800 or 1,000 is considerably cheaper than the latter, being comparable in cost to that of the mimeograph or multigraph. It is exceedingly satisfactory for scientific laboratory manuals, reading courses, synopses, reports, doctor or master theses and many other publications. The process is peculiarly adaptable to the reproduction of all black and white line material such as line drawings and diagrams as well as half-tones and photographs. Rare books or editions out of print may be reproduced for short runs at comparatively small expense, and whole articles or individual pages with their accompanying illustrations appearing in any publication may be duplicated in any specific size.

The process is briefly as follows: A typewritten sheet of any desired size is made, preferably on one of the typewriters with removable fonts of type which give almost as much variety of heading and body type as a regular type process. If there are illustrations, space is allowed for them on the sheet when typed and the page is made up as it is to appear. The complete manuscript for the article or publication is prepared in this way and photographed. Negative photographic films are developed and a final positive on sheet zinc is prepared, this latter being, of course, of the proper size to fit a rotary offset press. If the book is to be printed both sides, the make-up on the zinc sheet is laid out according to the usual book methods. If the book is a one-side printing, no such layout is necessary.

It will be seen from this brief description that the method is flexible and accommodating and can be used for a variety of purposes. It is also clear that the duplication is of such positive character, no one can say with justice that an article in this form is not "a publication." I am reporting it here with the thought that scientists and educational agencies of the country should know and appreciate the many advantages of this process.

GLENN M. HOBBS
W. M. WELCH MANUFACTURING COMPANY,
CHICAGO

SCIENTIFIC BOOKS

The Nature of Physical Theory. By VICTOR F. LENZEN, PH.D. John Wiley and Sons, New York, 1931, pp. 301.

THE author of this stimulating analysis of physical concepts and theories has had the advantage of a comprehensive training in both philosophy and physics. He divides the book into four parts: (I) "Special Classical Physical Theories," (II) "Unitary Systems of Physical Theory," (III) "The Quantum Theory" and (IV) "Methodological Principles," containing seven, five, two and two chapters, respectively. As the titles indicate, the text is informative as well as critical. In fact, the reader will find here a concise survey of the whole field of physical theory in a form demanding the minimum of familiarity with mathematical symbolism.

The author's program is to describe how the concepts of physical theory are derived from experience of aspects. Some discussion of the problem of subjectivism *versus* realism and the statement that the physicist, in the last analysis, employs a subjectivistic criterion of reality, indicates that the author is less convinced of the illusory character of this metaphysical distinction than is the average physicist. However, he properly adopts an empiricistic point of view and emphasizes the fact that concepts are abstractions from experience which are reached by a process of successive approximation.

The discussion of scalars and vectors, of space, time and kinematics is lucid and penetrating, but the analysis of the concepts of dynamics does not carry the same conviction. After emphasizing the importance of the selection of the frame of reference to which dynamical laws are to be referred, the author proceeds to the definition of force. This is taken up from the statistical point of view at first, and the definition is based on the anthropomorphic concept arising from the primitive experience of exertion. After defining work in terms of force he concludes by stating that "the principle of virtual displacements defines the concept of force." This principle may be considered as defining absence of force, but surely it can not be considered to define force unless the concept of work is presupposed.

Passing on to Newtonian kinetics the author offers two alternative points of view. Proceeding from the anthropomorphic definition of force derived from

statics, he defines momentum as a function of velocity which satisfies the integral relation between increase of momentum and impulse, in effect, Newton's second law of motion. This method, however, fails to disclose the simple functional form of the momentum and conceals the real content of the second law. His second method is somewhat more satisfactory. Here he starts by defining equality of momentum from a consideration of two bodies moving in opposite directions which come to rest upon collision. This gives him a unit of momentum in terms of which the momentum of a third body can be measured. Mass is the ratio of momentum to speed. In some ways this procedure is not as pleasing as that which starts with the definition of mass, since mass is an invariant, whereas momentum is not, but it is certainly significant. Finally he defines force as time rate of change of momentum. The author's second method, therefore, is pretty much the inverse of his first method. However, it makes Newton's second law of motion merely a definition, entirely devoid of physical content.

Now a definition is the process of attaching a word-label to a measurable quantity. Logically no one can quarrel with Kirchhoff's definition of force as time rate of change of momentum. The question is one of convention rather than logic. In solving the problem of the projectile do we put the force (identical with time rate of change of momentum) equal to mg, or do we equate the time rate of change of momentum to the force (identical with mg)? Certainly the latter is the general custom. Force, then, is something conceptually different from time rate of change of momentum which is related to it by a physical equation. Newton's second law of motion, too, is more than a definition and contains physical content. Is not its content expressed in the statement that the time rate of change of momentum is always equal to a definitive function (*i.e.*, one containing no arbitrary constants) of the coordinates? More briefly put, that the differential equations of motion are of the second order? This definitive function of the coordinates is what we mean by the force.

Part I continues with a critical discussion of classical electrodynamics and thermodynamics. At the conclusion of the first the author, after obtaining the circuital equations for electromagnetic fields in a polarizable and permeable medium, makes the statement that arguments may be adduced for the use of the vector B instead of H in these equations. Presumably he had in mind the equations in the form they take in empty space.

The second part of the book contains an illuminating account of the transition from the mechanical concept of nature to the electrodynamic concept and on to the geometrical concept. The discussion of both the special and the general relativity is especially to be commended to those who desire to obtain a clear understanding of the methods and objectives of the relativity theory without wading through a lengthy mathematical treatise. Although the author is concerned with unitary systems of physical theory, he does not mention the emission theory of electromagnetism in his two chapters on this subject.

The two chapters on quantum theory are too short to do justice to this rapidly growing subject, particularly as the first is devoted entirely to the Bohr-Sommerfeld theory. However, the fundamental features of the quantum mechanics are brought out, both from the point of view of the matrix representation of Born and Jordan and from that of the wave representation of Schrödinger. The author concludes this part by pointing out that science is now passing over to a symbolic conception of nature.

The last part of the work has to do with the methodology of science. Here the author brings out the fact that the important entities in nature are the invariants of physical theory. In every-day language, substance is that which is permanent. The book ends with a brief discussion of the concept of causality.

While the author has analyzed in considerable detail and with great penetration the concepts of theoretical physics, he pays too little attention to the objectives of theory. A satisfactory theory must account correctly for the facts observed: is this characteristic sufficient as well as necessary? Should a theory involve only quantities which are directly observable? If so, how is such a quantity to be distinguished?

Although written primarily for philosophers interested in science, the book should prove very valuable to physicists. For the concepts of science have their origin in philosophy, and some of the greatest advances in science have sprung from a critical examination of these concepts.

LEIGH PAGE

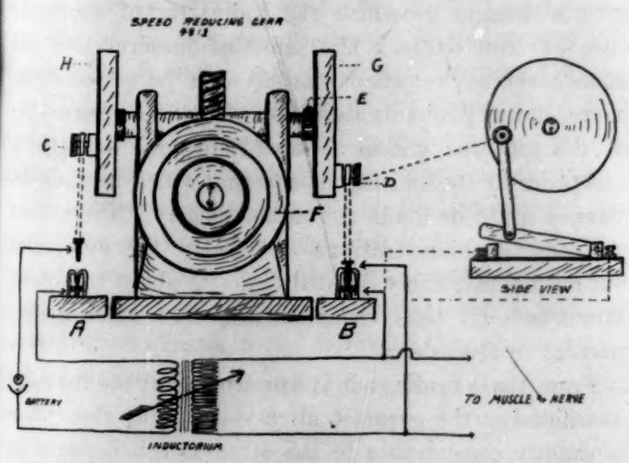
SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MOTOR-DRIVEN MAKE-BREAK STIMULUS SELECTOR

DURING the course of some recent investigations on muscle fatigue it became desirable to stimulate an isolated muscle preparation with maximal break induction shocks at one-second intervals, and simultaneously obtain a graphic record of all changes from the initial stimulus until the occurrence of complete

fatigue. In attempting this procedure by hand it was soon realized that the successful performance of the experiment necessitated considerable patience on the part of the operator, and such a degree of coordination of the hands, that not infrequently the investigator displayed signs of both muscular and nervous fatigue, while the isolated muscle was at its peak of activity. The desirability of some mechanical device for assisting in this phase of our experiment became apparent. A suitable apparatus for stimulating muscle and nerve preparations in the manner stated has been constructed from a speed-reducing gear, two single knife switches and an electric motor. Since the performance of this apparatus has been most satisfactory, both in the amount of time saved, and in its uniformity of action, its construction is presented here for any possible service it might render other investigators.

An essential part of the apparatus is a reducing gear with a speed ratio of 48:1. This is readily obtained from dealers in physical equipment at a nominal cost. An electric motor of fairly constant speed, usually 1750 r.p.m., is also required. The induction type A. C. motor is preferable. By the use of suitable pulleys the rotation speed of discs G and H (Diagram 1) is regulated to one revolution



per second. A and B are two single pole, single throw, knife switches, and are connected by metal strips of brass to eccentrically placed bearing surfaces C and D. The lengths of these bars are so adjusted, that when C and D are at their point of nearest approximation to switches A and B, the latter are fully closed. It is essential that one of these switches be completely insulated from the main body of the reducing gear. This is easily accomplished by means of a bushing of fiber or hard rubber contained in the disc at C or D, through which the brass bearing is inserted.

The knife switch A is connected in series with a battery, and the primary of an inductorium, in such a manner as to exclude the action of the vibrating interrupter. In other words, the primary is connected to produce single shocks. Switch B is a short-circuiting device, and is shunted across the secondary of the inductorium. The time relation of the opening and closing of switches A and B is regulated by the set screw E, which permits independent adjustment of the disc G with respect to H. For example, in stimulating by break induction shocks, set screw E is loosened, and by rotating disc G slightly forward, the position of D is advanced. The result is that B is opened, and is followed by the opening of A, and the production of a break induction shock.

This apparatus may be adapted to select the type of stimulus when employing either galvanic or faradic current, and leaves the operator's hands free to vary the intensity of stimulation.

W. R. BOND

DEPARTMENT OF PHYSIOLOGY,
MEDICAL COLLEGE OF VIRGINIA

CRYSTALLIZATION OF CERTAIN SALTS USED FOR THE DISINTEGRATION OF SHALES

ONE of the most difficult problems confronting everybody working on microfaunas is the breaking of shales containing microfossils and cleaning the latter of matrix. In several cases the writer used to get very satisfactory results soaking shales in hot saturated solution of sodium hyposulphite ("hypo," the common fixing salt of photographic practice). Since hypo is several times less soluble in cold water than in hot, crystallization begins at once as soon as the solution has been sufficiently cooled, accompanied by disintegration of shale. When disintegration was found incomplete, it was only necessary to warm the specimen, bring into solution hypo which had crystallized from cold water, and cool it again. The process can be repeated as many times as would be necessary to achieve the complete disintegration of shale or to realize that this particular shale could not be broken in this way. It was possible to attain complete and rather quick disintegration of a shale which had resisted boiling, even with alkalies. To a certain extent this process may be compared with freezing and thawing, used successfully by micropaleontologists in similar cases.[1] The whole operation can be carried on conveniently in the s. c. Kjeldahl flask of pyrex glass with long neck and round bottom. As has been shown by experience, they stand well without cracking repeated, and even quick, warming and cooling.

[1] G. D. Hanna and C. C. Church, "Freezing and Thawing to Disintegrate Shales," *Jour. of Paleontology*, ii, p. 131, 1928.

It happens often that the cold hypo solution, even highly oversaturated, does not crystallize. In this case a small grain of hypo dropped into solution produces an immediate effect—recrystallization of salt.

Certainly any other salt, differently soluble in cold and hot water, may be used for this purpose with the same result as hypo. F. e. sodium sulfate or washing soda are very good. In the case of washing soda the same solution may be used at first for boiling shale within and then, when boiling alone would be found insufficient, for crystallization through cooling.

I. TOLMACHOFF

CARNEGIE MUSEUM,
PITTSBURGH, PA.

SPECIAL ARTICLES

TOPOGRAPHIC SIMILARITIES BETWEEN MATERIALS REVEALED BY ULTRA-VIOLET LIGHT PHOTOMICROGRAPHY OF LIVING CELLS AND BY MICRO-INCINERATION[1]

LUCAS,[2] Wyckoff and Ter Louw,[3] Lucas and Stark,[4] and Wyckoff, Ebeling and Ter Louw[5] have recently published excellent ultra-violet photomicrographs of various living tissues. While examining these photographs, especially those of Wyckoff, Ebeling and Ter Louw, it occurred to me that there was a striking similarity between the shadow casting material (that which absorbed ultra-violet light of wave-length 2750 Å) and the mineral ash deposits in micro-incinerated cells of similar types. The idea is not altogether a new one, as Policard[6] had already pointed out that the calcium content of the nucleus might furnish an explanation of its capacity for absorbing ultra-violet rays as previously noted by Köhler.[7] The following observations were made in an attempt to ascertain the precise degree of similarity which exists. The method of microincineration employed was essentially that of Policard[8, 9] with some later modifications and improvements in methods of observation introduced by Scott[10, 11] and by Scott and Horning.[12]

(1) BACILLUS SUBTILIS

The ultra-violet photomicrographs of *B. subtilis* published by Wyckoff and Ter Louw serve as an excellent starting point, since the morphology of this organism is relatively simple. They show that the ultra-violet rays of wave-length 2750 Å are intensely absorbed by spores (Figs. 2, 4, 5 and 6). The authors indicate that the spores do not arise from a gradual merging together of preexisting cell bodies having similar physical properties. Indeed, at their first appearance they have already acquired their ultimate size and shape. Furthermore, the cytoplasm of spore-bearing cells is said to be of the same degree of opacity as the younger forms.

Smears of spore-bearing cultures of *B. subtilis* were dried in air and some colored with Giemsa's stain, while others were incinerated. The spore was found to be the locus of greatest mineral deposit. The residual ash was whitish grey tinged in places with a definite brownish red indicative of the presence of iron oxide. The mass of mineral was not doubly refractive when viewed with polarized light, hence, it was probably devoid of silica. The remainder of the cell was almost free of inorganic salts, with exception of its limiting membrane, which in most instances could be made out rather clearly. There were no definite concentrations of ash in the cytoplasm but only faint, finely divided deposits about the spore. Microchemical tests demonstrated that calcium was present in the ash.

From these findings it is apparent that the material which shows the greatest ultra-violet light absorption is exactly comparable to the mineral ash deposits in incinerated *B. subtilis*. Furthermore, a heavy deposition of salt in the spore lends weight to the frequently expressed opinion that spore formation is a concentration of cellular substance accompanying dehydration.

(2) RESTING NUCLEI OF TUMOR CELLS

Lucas gives photographs of cells of a mouse tumor which had previously been fixed and cut but not stained. In this particular instance the comparison of ultra-violet photographic results and those obtained by incineration is more exact, as tissues must of necessity be fixed in the course of preparation for the latter kind of study. In Lucas' Fig. 7 a number of "optical

[1] Aided by an appropriation from a grant made by the Rockefeller Foundation to Washington University for research in science.

[2] F. F. Lucas, *Proc. Nat. Acad. Sci.*, 16: 599, 1930.

[3] R. Wyckoff and A. Ter Louw, *J. Exp. Med.*, 54: 449, 1931.

[4] F. F. Lucas and M. Stark, *J. Morph. and Physiol.*, 52: 91, 1931.

[5] R. Wyckoff, A. Ebeling and A. Ter Louw, *J. Morph.*, 53: 189, 1932.

[6] A. Policard, *Bull. Hist. app.*, 5: 260, 1928.

[7] A. Köhler, *Zeitschr. f. wiss. Mikrosk.*, 21: 128 and 272, 1904.

[8] A. Policard, *Bull. Soc. Chim. Fr.*, 33: 1,551, 1923.

[9] A. Policard, *Protoplasma*, 7: 464, 1929.

[10] Gordon H. Scott, *Compt rend. Acad. Sci.*, 190: 1,323, 1930.

[11] Gordon H. Scott, *Proc. Soc. Exp. Biol. and Med.*, 29: 349, 1932.

[12] Gordon H. Scott and E. S. Horning, *J. Morph.*, 53: 1932, in press.

sections" of a fixed section of mouse tumor are pictured. One is struck almost immediately by the hyperchromatic condition of the nuclei of the tumor cells, which supports Cowdry's[13] observation that in tissue cultures they exhibit a more pronounced Feulgen reaction than do non-malignant cells. The formed chromatic material is densely packed at the margin of the nucleus, with one or more heavy flakes, which may perhaps be nucleoli, near its center. The cytoplasm of the tumor cells shows a rather greater absorbing power for the ultra-violet rays than one expects after examining photographs of other types of normal cells. Definite granules are quite prominent in the cytoplasm.

The micro-incineration method has already been used in the study of neoplastic tissues by Policard and Doubrow[14] and by Scott and Horning,[15, 16] and photographs and drawings are available in the literature. When incinerated sections of a neoplasm are examined the observer is at once aware of the large amount of mineral ash in the cells. The area of invading growth is clearly delimited from the surrounding stromal tissue by its increased salt content (Fig. 1, Scott and Horning). In the cells shown in Fig. 2 (Scott and Horning) the increased ash deposit at the periphery of the nucleus is brought out clearly. The arrangement and distribution of the mineral deposit corresponds in every way to the formed chromatic material of the stained nucleus. A comparison of Lucas, Figs. 7 and 9 with Scott and Horning's Figs. 1 and 2 leaves but little doubt of the similarity of the nuclear materials shown by ultra-violet photomicrography and those remaining after micro-incineration.

The relatively heavy density of the cytoplasm—its absorptive power for ultra-violet light—is in keeping with the results obtained by incineration. Neoplastic cells of the types examined showed a greater concentration of salt in the cytosome than did normal cells of similar types.

(3) Tissue cultures of fibroblasts

Wyckoff, Ebeling and Ter Louw have discussed the similarity in appearance of ultra-violet photomicrographs and Feulgen staining of cells in tissue cultures. Their comparison, to be sure, is more or less fortunate as regards the formed chromatic material but not so of the cytoplasmic constituents common to protoplasm. Their photographs show that in the nuclei of resting fibroblasts the only material strongly absorbing ultra-violet rays is that of the nucleolus but that the nuclear membrane is distinct (especially Figs. 3 and 4). The nucleoplasm has practically the same translucency as the cytoplasm. Flakes of chromatin are frequently seen in the nucleus. In Fig. 2 (Wyckoff, Ebeling and Ter Louw) a fibroblast is illustrated which has many small highly absorptive granules scattered throughout its cytoplasm. Amongst these granules are seen several vacuolar structures which possess rims not transparent to ultra-violet light. The fibroblasts of their Figs. 1, 3 and 4 also show the same structures.

Micro-incinerated specimens of fibroblasts and fibroblast-like cells have been described by Horning and Scott.[17] The nucleolus leaves a residue of very dense, whitish ash simulating in appearance the structure revealed in Wyckoff, Ebeling and Ter Louw's Figs. 1, 2, 3 and 4. Occasionally the rim of the nucleus can be made out as a distinct ash deposit arranged in a very fine line. In some instances tiny bead-like deposits are visible at the margin of the nucleus quite like those shown in Fig. 3 (Wyckoff, Ebeling and Ter Louw).

The cytoplasmic residue of incinerated fibroblasts gives an appearance almost exactly like that seen in the ultra-violet photographs. There are in some instances diffuse deposits with larger clumps of ash of an entirely different appearance scattered about in an irregular fashion. In other cells large, empty, ring-like spaces with heavy borders of mineral material are found. The appearance of a similar type of cell after incineration is shown in Fig. 1 (Horning and Scott). The boundaries of the incinerated tissue culture cell are usually sharply outlined by a definite ash deposit. A comparison of Fig. 2 (Wyckoff, Ebeling and Ter Louw) with Fig. 1 (Horning and Scott) shows that the minute granules in the ultra-violet photographs are of the same order of magnitude as the individual ash deposits in the incinerated cell. This point has been checked by measurements at the same magnification of the granules in the photograph and in the incinerated cells. The average diameter of the light-absorbing masses in the photograph is calculated to be equal to 0.83 microns in the living cell, whereas the mean diameter of the ash deposits is 0.79 microns.

(4) Tissue Cultures of Macrophages

Wyckoff, Ebeling and Ter Louw's Fig. 12 shows the nucleus and the surrounding cytoplasm of macrophages to have about the same opacity to ultra-violet light; but there are present in the cytoplasm certain intensely absorbent granules.

[13] E. V. Cowdry, SCIENCE, 68: 40, 1928.

[14] A. Policard and S. Doubrow, *Ann. d'Anat. path.*, 1: 163, 1924.

[15] Gordon H. Scott and E. S. Horning, *Proc. Soc. Exp. Biol. and Med.*, 29: 708, 1932.

[16] Gordon H. Scott and E. S. Horning, *Amer. J. Path.*, 8: 329, 1932.

[17] E. S. Horning and Gordon H. Scott, *Proc. Soc. Exp. Biol. and Med.*, 29: 704, 1932.

Examination of macrophages which have been incinerated shows very little ash in the nucleus; the nucleolus leaves a definite residue though the nuclear membrane is very feebly marked. The cytoplasm is filled with heavy, highly refractive masses of ash which are birefringent in polarized light, indicating the presence of silica. These ash deposits are obviously the remains of granules similar to those showing so clearly in the ultra-violet photographs.

(5) Nucleated Erythrocytes

When adult chicken erythrocytes are photographed with ultra-violet light the nucleus shows as a highly absorbing mass revealing but little structure (Fig. 8, Wyckoff, Ebeling and Ter Louw). The cytoplasm is moderately dense, indeed rather more so than that of the fibroblasts and macrophages.

Adult chicken blood was prepared in a thin, even smear and incinerated. The nuclei appeared as dense deposits of greyish white ash quite sharply separated from the surrounding cytoplasm. The cytoplasmic residue was finely granulated and evenly distributed throughout the cell. The limiting membrane of the erythrocyte was not at all sharply defined, but since the blood plasma leaves little or no residue, difficulty was not experienced in determining cell boundaries.

(6) Sperm Cells

Lucas and Stark have published excellent ultra-violet photomicrographs of living sperm cells of the grasshopper. As their study is primarily one of certain differences in chromosome formation, they have pictured but few resting cells. In Fig. 1 of their paper there are three large cells near the center which may well be true examples of the resting nucleus. A close examination of these cells shows the nucleus to be quite distinctly outlined. There are definite though faint flakes of chromatic material present. In Figs. 3 and 4 of Lucas and Stark's article the true resting nucleus is admirably shown in the sustentacular cells. In these nuclei the nucleolus absorbs the ultra-violet light and hence appears as a marked shadow. The nuclear membrane is sharp and patches of chromatin material are visible.

Preparations were made of testes fixed in absolute alcohol and formalin and of rapidly dried fresh smears. The resting spermatocytes showed but slight ash in the nucleus. The nucleolus was always represented by a highly refractile deposit of minerals and occasional ash clumps were scattered throughout the nucleus.

(7) Cells during Mitosis

The actual process of cell division with the coincident formation of chromosomes in living sperm cells, as observed with the ultra-violet microscope, has been described by Lucas and Stark. Their findings are well illustrated. In general it can be said that the chromosomes absorb ultra-violet light and consequently appear to be very dark in the photograph. This holds true for all stages of division, from the earliest prophase to the daughter cells. The cytoplasm of cells in most of the earlier stages of mitosis seems to be quite transparent and cell membranes are rather indistinct (Figs. 6 and 7, Lucas and Stark). It is significant that there are no marked granulations in the cytoplasm in the later stages.

Incinerated sperm cells of grasshoppers were examined and the arrangement of the salts noted during division. The findings in this form differed in no essential respect from those in the skin of the frog and in the testicle of the white rat previously recorded by Scott.[18] In each instance chromosome form was perfectly preserved by the ash residue and but little mineral matter could be seen in other portions of the cell. Even the early changes in the division figures could be followed with considerable accuracy.

Sperm cells of different orders do not appear to vary in the inorganic constituents revealed by micro-incineration. Dividing cells of the cat and rat testicle, frog skin, intestinal epithelium of rat and of cat, epidermis of *Triturus viridescens* and developing eggs of the frog, all show a concentration of mineral in the formed chromatin—especially in the chromosomes. Very little, if any, ash residue can be seen in other parts of the nucleus either of resting cells or of cells undergoing mitosis.

Evidently in these several kinds of material available for comparison, there is a definite resemblance between the topographic distribution of the substances of the living cell which are opaque to ultra-violet light of certain wave-lengths, and the mineral ash deposits in incinerated cells of similar types. With the present evidence it is impossible to decide whether the material absorbing ultra-violet light in living cells acts as a surface or focus of crystallization for the mineral materials in the process of fixation and dehydration, or represents an area of protoplasm composed largely of an inorganic colloidal complex. The conclusion is warranted that these two techniques (ultra-violet light photography and micro-incineration) are mutually supportive insofar that they reveal the presence of similar substances. Together they constitute a new and valuable method for the investigation of the chemical constitution of living matter.

Gordon H. Scott

Washington University
School of Medicine

[18] Gordon H. Scott, *Bull. Hist. app.*, 7: 251, 1930.